

# MEMO

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Date:

November 30, 2016

Arcadis Project No.:

B0009989.0050

Subject:

Summary of Preliminary Receptors, Exposure Factors, and Toxicity  
Reference Values Selection for the Newark Bay Study Area Baseline  
Ecological Risk Assessment

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On behalf of Tierra Solutions, Inc. (Tierra), Arcadis U.S., Inc. (Arcadis) will prepare a Draft Baseline Ecological Risk Assessment Report (Draft BERA Report) for the Newark Bay Study Area (NBSA) in 2017 as part of the ongoing remedial investigation (RI)/feasibility study (FS) process pursuant to the Administrative Order on Consent, United States Environmental Protection Agency (USEPA) Index No. CERCLA-02-2004-2010. The baseline ecological risk assessment (BERA), initiated in 2011, is being conducted in a stepwise process under the RI/FS, as described below. This memorandum was prepared to help develop an initial framework for the Draft BERA Report.

## 1 BACKGROUND

The NBSA BERA process began with a 2-day workshop hosted by the USEPA Region 2 in Edison, New Jersey on June 28 and 29, 2011. Representatives from the USEPA and its consultants, Tierra and its consultants, and various federal and state regulatory agencies participated in the workshop. The workshop outcome is summarized in meeting minutes/notes developed by Tierra (2011) and approved by the USEPA.

Following the workshop, Tierra produced the Problem Formulation Document (PFD; Tierra 2013). The goal of the PFD (Tierra 2013) was to “establish the overall goals, breadth, and focus of the baseline ecological and human health risk assessments and to define the questions that need to be addressed during these evaluations.” From an ecological risk standpoint, the objectives of the PFD (Tierra 2013) were to:

- Compile and summarize the relevant available information (at the time) for the NBSA
- Develop an ecological conceptual site model (CSM) for the NBSA

- Conduct a conservative screening-level ecological risk assessment to determine which chemical constituents would likely be evaluated in the BERA
- Select receptors for the BERA and develop risk questions, assessment endpoints (AEs), and measurement endpoints (MEs) for these receptors.

Following completion of the PFD (Tierra 2013), Tierra and the USEPA determined the data needs and scopes of work for data collection for the BERA. As part of this process, Tierra conducted an ecological field reconnaissance of the NBSA (Tierra 2015a) to refine the understanding of the habitats and potential ecological receptor use of the NBSA environs, as well as to help select appropriate sampling locations for the BERA data collections.

The data needs for the BERA and basis for sampling (sample type, numbers, and locations) are summarized in a risk assessment scoping memorandum (Tierra 2015b) that was developed in an iterative manner by Tierra and the USEPA between 2013 and 2015. The scoping memorandum (Tierra 2015b) contains an updated version of the original table of AEs and MEs for the NBSA BERA from the PFD (Tierra 2013).

The BERA sampling program was implemented in stages between 2014 and 2016 and is now complete. It included three sampling programs:

1. Clam, crab and co-located surface sediment sampling
2. Sediment quality triad (SQT; synoptic data on surface sediment chemistry, sediment toxicity, benthic communities, and invertebrate bioaccumulation) and co-located porewater sampling
3. Fish tissue and community sampling.

The specific sampling programs are described in a series of Quality Assurance Project Plans (Tierra 2014a, 2014b, 2015c). The field investigation and data results from the BERA sampling are summarized in a series of draft reports:

- Clam and crab field investigation and data reports (Tierra 2016a, 2016b)
- SQT and porewater field investigation and data reports (Tierra 2016c, 2016d)
- Fish field investigation and data reports (Tierra 2016a, 2016e).

These BERA datasets, in conjunction with the sediment chemistry data from Phases I and II of the RI, and data presently being collected under Phase III of the RI, will constitute the site-specific data to be used to conduct the risk assessments (i.e., both ecological and human).

## 2 OBJECTIVES AND APPROACH

This memorandum summarizes the initial evaluation of the appropriate receptors to be evaluated in the BERA, assessment areas for these receptors, exposure factors for each receptor, and a preliminary list of toxicity reference values (TRVs) that will be used to evaluate potential risks to these receptors. A more refined evaluation of these parameters will be developed during the implementation of the BERA.

The benthic invertebrate risk assessment for the NBSA BERA will largely be completed under the SQT assessment. That process will involve statistical evaluations of the surface sediment chemistry, porewater

chemistry, laboratory sediment toxicity, and benthic community data that were synoptically collected under the SQT sampling program. It will also consider the results of the invertebrate (i.e., polychaete worm) bioaccumulation tests that were collected as part of the program. The approach to conducting the SQT for the BERA is summarized in the November 14, 2016 Arcadis memorandum entitled *Approach to Conducting the Sediment Quality Triad Assessment for the Newark Bay Study Area*. Therefore, the only aspect of the benthic invertebrate risk assessment that is included in this memorandum is the selection of preliminary tissue-based TRVs for comparison to the invertebrate tissue data collected for the NBSA (i.e., worms, clams, and crabs).

The USEPA's goal in the BERA process for the NBSA is to maintain consistency with the processes and assessment approaches for the Lower Passaic River Restoration Project (LPRRP). A revised BERA for the LPRRP was recently submitted to the USEPA by the Cooperating Parties Group (CPG; Windward 2016). The revised BERA was updated from an earlier draft to reflect comments and directives from the USEPA and its partner agencies. The revised BERA (Windward 2016) represents a large amount of work and the results of long-term negotiations between the CPG and the USEPA. Given the connectivity of the estuarine/marine portion of the Lower Passaic River (LPR) and the NBSA, and the fact that the LPRRP BERA process is in an advanced stage, Arcadis has adopted—when technically appropriate—the receptors, exposure factors, and TRVs from the LPRRP BERA for use in the NBSA BERA.

Most notably, the CPG conducted a detailed literature search and developed a database of available TRVs for the constituents of potential ecological concern (COPECs) that were evaluated in their BERA. This database includes TRVs from studies for survival, growth, and reproductive effects in a wide variety of invertebrate, fish, bird, and mammal species, including the types of receptors found in the estuarine/marine portion of the LPR and the NBSA. As such, the TRV database was used to select preliminary TRVs for the NBSA BERA. Arcadis will also conduct an updated literature search on TRVs as one of the initial steps of the BERA process in 2017.

While there is connectivity between the LPR and the NBSA, and many of the BERA components and risk-related issues are the same, the NBSA is different from the LPR in terms of its physiography (i.e., open saltwater bay vs. transitional estuarine river), habitats, and ecology. For this reason, the NBSA BERA, while following a similar process and comparable steps as the LPRRP BERA, will be structured to assess potential risks in the marine ecosystem of Newark Bay. This has been accounted for in the initial evaluation of potential receptors, exposure factors, and TRVs presented in this memorandum, pursuant to the ecological CSM presented in the PFD (Tierra 2013).

### 3 NEWARK BAY STUDY AREA RECEPTORS, ASSESSMENT/MEASUREMENT ENDPOINTS, AND PRELIMINARY CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN

The receptor groups, AEs, MEs, and associated site-specific datasets are summarized in Table 1. This table is an updated version of the table from the risk assessment scoping memorandum (Tierra 2015b) and reflects updated knowledge of the NBSA receptors from the various field investigations and specific datasets that were collected for the BERA.

The preliminary list of COPECs considered in this evaluation consist of the prominent groups of contaminants identified in the PFD and those assessed in the LPRRP BERA. These include:

- Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDD/PCDFs) represented by seventeen 2,3,7,8-substituted congeners
- Polychlorinated biphenyls (PCBs)
- Polycyclic aromatic hydrocarbons (PAHs)
- Pesticides—represented by dichlorodiphenyltrichloroethane (DDT) and its metabolites as a group (referred to collectively as DDTx), chlordane, dieldrin, and hexachlorobenzene
- Mercury/methylmercury
- Inorganic chemicals (primarily metals).

As an initial step in the BERA, an updated screening assessment will be conducted to determine any additional COPECs that will need to be evaluated. It is anticipated that this may include additional pesticides and a group of (non-PAH) semivolatile organic compounds. Once the final list of COPECs is generated, TRVs for the additional compounds (not identified in the list above) will be selected. At this early stage in the process, the database from the BERA sampling programs has not been developed to a point where the screening analysis step can be completed.

The AEs and MEs presented are those agreed upon by Tierra and the USEPA during the scoping of the risk assessment, prior to implementation of the BERA field programs, as reported in Tierra (2015b). The receptor groups for which AEs were identified include invertebrates (infaunal communities and epibenthic clams and crabs), fish, reptiles, birds, and mammals. The receptors selected to represent each of these groups are provided in Table 2. The selection of the receptors in Table 2 was based on a review of historical NBSA ecological studies (Tierra 2013) and results of the ecological field reconnaissance (Tierra 2015a) and BERA data collections (Tierra 2016a through 2016e).

Additional AEs were originally identified in the PFD for aquatic plants and reptiles. However, based on the results of the field reconnaissance conducted prior to field sampling for the BERA (Tierra 2015a), it was determined that vegetation in the NBSA is limited to pockets of shoreline areas surrounding the Bay, and is mainly upland vegetation, except for some of the small intertidal mudflat areas that contain limited

wetlands vegetation. For this reason, aquatic vegetation was removed as an AE from the BERA, and instead will be addressed as a discussion in the uncertainty section. Similarly, there is little evidence of reptile use of the NBSA. Because of their limited potential occurrence and the lack of available species-specific TRVs, reptiles will be evaluated as part of the uncertainty assessment in the BERA.

The risk assessment will be conducted for local assessment zones in the NBSA as shown on Figure 1. Risks will be estimated both on a bay-wide and assessment zone basis. The breakdown of assessment zones was developed in consideration of the ecological CSM for the NBSA (e.g., physiography, source pathways, tributaries, geomorphic units, depth), differences in habitat (and potential exposure) areas, and the need to try to differentiate and localize where potential risks may be originating. This breakdown will improve the usefulness of the BERA relative to the bay-wide results for risk management decision-making, because it will allow a comparison between bay-wide risk estimates to those on a more local exposure scale, thus allowing risk managers to examine and isolate potential focus areas for remedial considerations or further investigation.

## 4 EXPOSURE ASSESSMENT

The approach and parameters that will be used for the two key components of the exposure assessment for the NBSA BERA are discussed below and include:

- Calculation of exposure point concentrations (EPCs) from site-specific data
- Selection of exposure factors that will be used to estimate potential risks for the representative receptors that will be evaluated.

These are briefly discussed below for the different receptor groups that will be evaluated in the BERA. A comprehensive evaluation of exposure parameters will be provided in the BERA for each receptor group.

### 4.1 Exposure Point Concentrations

EPCs are statistical representations of the chemical concentrations measured in surface water, surface sediment, porewater, and tissue samples of organisms from the NBSA. EPCs for each of the media will be calculated on both a bay-wide and more local assessment zone basis. The assessment zones will be the seven areas identified on Figure 1. Within each of the zones, summary statistics will be calculated for the data collected for each of the media. For biota tissue data, these statistics will be calculated on a species- and tissue-specific basis, and will include wet weight (ww) and lipid-normalized summaries, as appropriate. Similarly, sediment data will be summarized on a dry weight (dw) and organic carbon basis, as appropriate.

Summary statistics (e.g., number of samples, detection frequency, minimum, maximum, mean, standard deviation) will be provided for each of the media by assessment zone. The mean and the 95 percent upper confidence limit on the mean will be provided as the primary input parameters to the exposure risk equations. Discussions of the site-specific data and the differences between assessment zones will be key components of the BERA. Descriptions of the sample types and numbers, as well as initial statistical summaries of the data from the BERA sampling programs, were provided in recent (non-interpretive) draft data reports (Tierra 2016b, 2016d, 2016e).

## 4.2 Exposure Factors

The risk assessment for benthic invertebrates is being conducted primarily using the SQT assessment. Additional analyses will include comparing whole body tissue data (measured and estimated) for infaunal invertebrates (i.e., represented by polychaete worms) and epibenthic softshell clams (mollusks/bivalves) and blue crabs to TRVs selected for invertebrates. This will be done on a bay-wide and assessment zone-specific basis. There are no exposure factors needed to conduct this analysis, only the tissue data and TRVs.

Similarly, the risk assessment for fish will also be conducted using a direct comparison of tissue data collected for the target species in the NBSA to fish TRVs. Both the fish and invertebrate tissue comparison process are discussed further in the TRV section of this memorandum.

Birds and mammal exposure risks will be evaluated using food web models that estimate the average daily dietary dose of COPECs to these receptors, and compare these doses to ingestion-based TRVs. For each group, representative receptors from different feeding guilds (e.g., omnivores, invertivores, piscivores) will be evaluated as summarized in Table 2.

The food web models incorporate a range of life history data for the species being modeled, as well as site-specific input data on food items, COPEC concentrations in the food items, and area use. These are collectively referred to as the exposure factors. The selected parameters/values for the exposure factors by bird and mammal species are provided in Tables 3, 4, and 5. The exposure factors for each receptor group, including any food web modeling equations and the input parameters/assumptions for the models, are summarized below.

### 4.2.1 Birds

Potential risks to birds will be assessed in the BERA using ingestion-based food web models and egg data. Inputs to the food web models will include site-specific data collected on COPECs in bird food items, including benthic (infaunal) invertebrates (represented by polychaete bioaccumulation test data), clams, blue crab, fish, and sediment (i.e., incidental ingestion and surrogate for vegetation ingestion); and published exposure factors/life history data from the scientific literature. The dietary assessment will be conducted for sediment probing (spotted sandpiper), insectivorous (marsh wren), and piscivorous (great blue heron, double-crested cormorant) birds; and waterfowl (lesser scaup).

#### 4.2.1.1 Food Web Model

Dietary doses for birds will be estimated based on ingestion of biota (i.e., prey) and the incidental ingestion of sediment. Ingestion of surface water is not included in the equation because all water in the NBSA is saltwater and not used by birds as drinking water. Any ingestion of saltwater would be incidental and have a negligible effect on risk. Dietary doses will be estimated as milligrams of each COPEC ingested per kilogram of body weight per day using the following equation:

$$Dose = \frac{[(FIR \times EPC_{prey}) + (SIR \times EPC_{sed})]}{BW} \times SUF$$

Where:

Dose	=	daily ingested dose milligrams per kilogram (mg/kg) body weight per day (bw/day)
FIR	=	food ingestion rate (kg dw/day)
EPC <sub>prey</sub>	=	exposure point concentration of chemical in prey tissue (mg/kg dw)
SIR	=	incidental sediment ingestion rate (kg dw/day)
EPC <sub>sed</sub>	=	exposure point concentration of chemical in sediment (mg/kg dry weight [dw])
BW	=	body weight (kg)
SUF	=	site use factor (SUF) (unitless); proportion of time the selected species spends foraging in the NBSA

Body weights, ingestion rates, and SUFs were obtained from the literature for each representative species being modeled and are presented in Table 3.

The EPC for prey for each receptor species will be calculated from the fractions of different prey types in the respective species' diet and the EPCs for each of those prey types, as follows:

$$EPC_{prey} = (EPC_1 \times F_1) + (EPC_2 \times F_2)$$

Where:

EPC <sub>prey</sub>	=	exposure point concentration in prey items (mg/kg dw)
EPC <sub>1,2</sub>	=	exposure point concentration in each individual prey type (mg/kg dw)
F <sub>1,2</sub>	=	fraction ingested of each individual prey type (kg prey/kg food)

The dietary fraction of each component in each species' diet is based on information obtained from the literature.

The SUFs and exposure areas for the representative bird receptors are provided in Tables 3 and 4, respectively.

#### 4.2.1.2 Egg Tissue Assessment

As an additional assessment of reproduction in birds, potential risks to bird eggs from maternal dietary exposure will be evaluated in two species: great blue heron and double-crested cormorant. In this assessment, biota (prey) tissue data will be converted into modeled egg tissue data based on an assumption of biomagnification from adult bird food items to their eggs and the development of an NBSA-specific bird egg biomagnification factor (BMF). This assessment will be limited to highly bioaccumulative compounds that are known to pose potential reproductive risks in water birds, including mercury/methylmercury, PCDD/Fs, PCBs, and pesticides.

Site-specific egg tissue data are available for cormorants from the NBSA as reported by Parsons (2003). As such, no BMF is needed for this species. For the great blue heron, COPEC concentrations in eggs will be estimated using the following equation:

$$EPC_{egg} = EPC_{prey} \times BMF$$

Where:

EPC <sub>egg</sub>	=	exposure point concentration in bird egg tissue(s) (mg/kg ww)
EPC <sub>prey</sub>	=	exposure point concentration in prey tissue (mg/kg ww)

The BMF will be calculated in the BERA from the site-specific double-crested cormorant and fish/invertebrate tissue data from the NBSA. This will be done on a bay-wide and assessment zone basis.

## 4.2.2 Mammals

Potential risks to mammals will be assessed in the BERA using ingestion-based food web models. Inputs to the food web models will include site-specific data collected on COPECs in potential mammal food items, including benthic (infaunal) invertebrates (represented by polychaete bioaccumulation test data), clams, blue crab, fish, and sediment (i.e., incidental ingestion and surrogate for vegetation ingestion); and published exposure factors/life history data from the scientific literature.

The dietary assessment will be conducted for omnivorous (muskrat) and piscivorous (river otter and harbor seal) mammals. A third feeding guild, the insectivorous mammal, is discussed in the PFD (Tierra 2013). However, this feeding guild was not included in the current list of receptors because there are no emergent insects present in the NBSA and, therefore, this is an incomplete exposure pathway.

### 4.2.2.1 Food Web Model

Dietary doses for mammals will be estimated based on ingestion of biota (i.e., prey) and incidental ingestion of sediment. Ingestion of surface water is not included in the equation because all water in the NBSA is saltwater and not used by mammals for drinking. Any ingestion of saltwater is incidental and will have a negligible effect on risk.

Dietary doses will be estimated as milligrams of each COPEC ingested per kilogram of body weight per day using the following equation.

$$Dose = \frac{[(FIR \times EPC_{prey}) + (SIR \times EPC_{sed})]}{BW} \times SUF$$

Where:

- Dose = daily ingested dose (mg/kg bw/day)
- FIR = food ingestion rate (kg dw/day)
- $EPC_{prey}$  = exposure point concentration of chemical in prey tissue (mg/kg dw)
- SIR = incidental sediment ingestion rate (kg dw/day)
- $EPC_{sed}$  = exposure point concentration of chemical in sediment (mg/kg dw)
- BW = body weight (kg)
- SUF = site use factor (SUF) (unitless); proportion of time the selected species spends foraging in the NBSA

Body weights, ingestion rates, and SUFs were obtained from the literature for each representative receptor species and are provided in Table 5.

The EPC for prey for each focal species will be calculated from the fractions of different prey types in the focal species' diets as follows:

$$EPC_{prey} = (EPC_1 \times F_1) + (EPC_2 \times F_2)$$

Where:

- $EPC_{prey}$  = exposure point concentration in prey items (mg/kg dw)
- $EPC_{1,2}$  = exposure point concentration in each individual prey type (mg/kg dw)
- $F_{1,2}$  = fraction ingested of each individual prey type (kg prey/kg food)



The dietary fraction of each component in each species' diet is based on information obtained from the literature. The muskrat is assumed to use the NBSA for the entire year, however the river otter and harbor seal are transient in the NBSA and assumed to be present for only 50% of the time. The exposure areas and SUFs for each species and their basis are presented in Tables 4 and 5.

## 5 TOXICITY REFERENCE (EFFECTS) VALUES

This section presents the preliminary suite of effects data (i.e., TRVs) selected from the toxicological literature for the initial list of COPECs identified in Section 3. As previously stated, the intention of this memorandum is to preliminarily identify TRVs at this early stage of the BERA process. A more thorough and refined evaluation of TRVs will be conducted as an initial step of the BERA process, once the screening-level assessment is conducted and the final list of COPECs is identified. This will be conducted in consultation with USEPA and its consultants.

A range of TRVs were evaluated. The selection was based on a comprehensive review of the pertinent literature and an evaluation of acceptability, as conducted and described by the CPG for the LPRRP (Windward 2016, Appendix E), and reviewed by Arcadis.

### 5.1 Preliminary TRV Selection Approach

The CPG (Windward 2016) conducted a detailed literature search and developed a database of available TRVs for the COPECs that were evaluated in the LPRRP BERA. This database includes TRVs from studies on survival, growth, and reproductive effects in a wide variety of invertebrate, fish, bird, and mammal species, including the types of receptors found in the estuarine/marine portion of the LPR and the NBSA. For this reason, and to be consistent with the LPR process, this TRV database was used to select preliminary TRVs for the NBSA BERA. Consideration was also given to comments provided by USEPA on the CPG's TRVs during this selection process. Arcadis will also conduct an updated literature search on TRVs as one of the initial steps of the BERA process in 2017, and work with USEPA and its consultants to select the set of final TRVs for risk characterization and uncertainty assessment.

For each receptor group, two TRV values were targeted for selection: 1) a low-observed-adverse-effects level (LOAEL), and 2) a no-observed-adverse-effects level (NOAEL). For some COPECs, only one of these values is available from the existing literature and, in some instances, no TRVs are available. In these cases, the impact of these limitations will be discussed in the uncertainty assessment of the BERA, as was done in the LPRRP BERA. Arcadis will also attempt to identify or derive additional TRVs to help fill gaps during the 2017 BERA process. Similar to the approach used in the LPRRP BERA, LOAEL TRVs will be used in the NBSA BERA in the discussion of risk characterization. The NOAELs will be included for informational purposes and discussion in the uncertainty assessment.

In evaluating the CPG database and TRVs used in the LPRRP BERA, consideration was given to the differences in the physiography and habitats of the NBSA vs. LPR (i.e., open saltwater bay vs. estuarine/freshwater river), and receptor types that utilize the habitats in each. The focus of the TRV selection for benthic invertebrates and fish for the NBSA was on available values for saltwater species. When saltwater species TRVs were not available for a COPEC, freshwater species TRVs were used. For birds and mammals, the species differ somewhat between the NBSA and LPR, but the TRVs are the

same in most cases, as they are based on the same limited suite of available bird and mammal toxicity studies.

## 5.2 Preliminary Suite of TRVs

The preliminary list of benthic invertebrate tissue TRVs is presented in Table 6. These TRVs will be used in the tissue assessment to be conducted for benthic invertebrates, including the infaunal invertebrate community (represented by polychaete tissue data), softshell clam (mollusks/bivalves), and blue crab data from the NBSA.

The preliminary list of fish tissue TRVs is presented in Table 7. These will be used in the whole body and liver tissue assessment for the various fish species collected and analyzed for the BERA.

There are several differences between the preliminary benthic invertebrate and fish tissue TRVs selected for the NBSA and those used for the LPRRP BERA. These are noted in Tables 6 and 7, respectively. These differences are almost exclusively based on the selection of marine values wherever possible for the NBSA, whereas the TRVs for the LPRRP were based almost exclusively on studies of freshwater organisms/species.

The preliminary lists of bird ingestion and egg TRVs are presented in Tables 8 and 9, respectively, and the ingestion TRVs for mammals are presented in Table 10. There are few differences between the preliminary NBSA and LPRRP TRVs for birds, and no differences for mammals. The reason for this is that the toxicological data for these organisms are limited, and TRVs are typically based on surrogate species from the range of studies that are available. Despite this limitation, there are a range of toxicology studies that have been conducted on wild birds for many of the preliminary COPECs. Where wild bird studies were available, TRVs were selected from these datasets and excluded data from studies on domestic birds—primarily chickens. This is appropriate, as domestic chickens have been shown in numerous studies to be substantially more sensitive to contaminant effects than wild birds (USEPA 2003). As such, they do not represent a reasonable surrogate receptor to assess risks for wild birds.

As discussed above, the lists of TRVs presented in Tables 6 through 10 will be re-evaluated and refined as part of the initial steps in the implementation of the BERA, and following the screening assessment to select the final list of COPECs. As part of these efforts, additional literature evaluations will be conducted to determine if updated data are available for key COPECs.

## 6 SUMMARY

This memorandum summarizes the initial evaluation of the appropriate receptors to be evaluated in the BERA, assessment zones for these receptors, exposure factors for each receptor, and a preliminary list of toxicity reference values (TRVs) that will be used to evaluate potential risks to these receptors.

The USEPA's goal in the BERA process for the NBSA is to maintain consistency with the processes and assessment approaches for the LPRRP. Therefore, it is Tierra's goal to maximize the use of the BERA prepared by the CPG for the LPR (Windward 2016), which represents a large amount of work and the results of long-term negotiations between the CPG and the USEPA. Given the connectivity of the estuarine/marine portion of the LPR and the NBSA, and the fact that the LPRRP BERA process is in an

advanced stage, Arcadis has adopted—when technically appropriate—the receptors, exposure factors, and TRVs from the LPRRP BERA for use in the NBSA BERA.

While there is connectivity between the LPR and the NBSA, and many of the BERA components and risk-related issues are the same, the NBSA is different from the LPR in terms of its physiography (i.e., open saltwater bay vs. transitional estuarine river), habitats, and ecology. For this reason, the NBSA BERA, while following a similar process and comparable steps as the LPRRP BERA, will be structured to appropriately assess potential risks in the marine ecosystem of Newark Bay. This has been accounted for in the initial evaluation of potential receptors, exposure factors, and TRVs presented in this memorandum, pursuant to the ecological CSM presented in the PFD (Tierra 2013). A more refined evaluation of these parameters will be developed during the implementation of the BERA.

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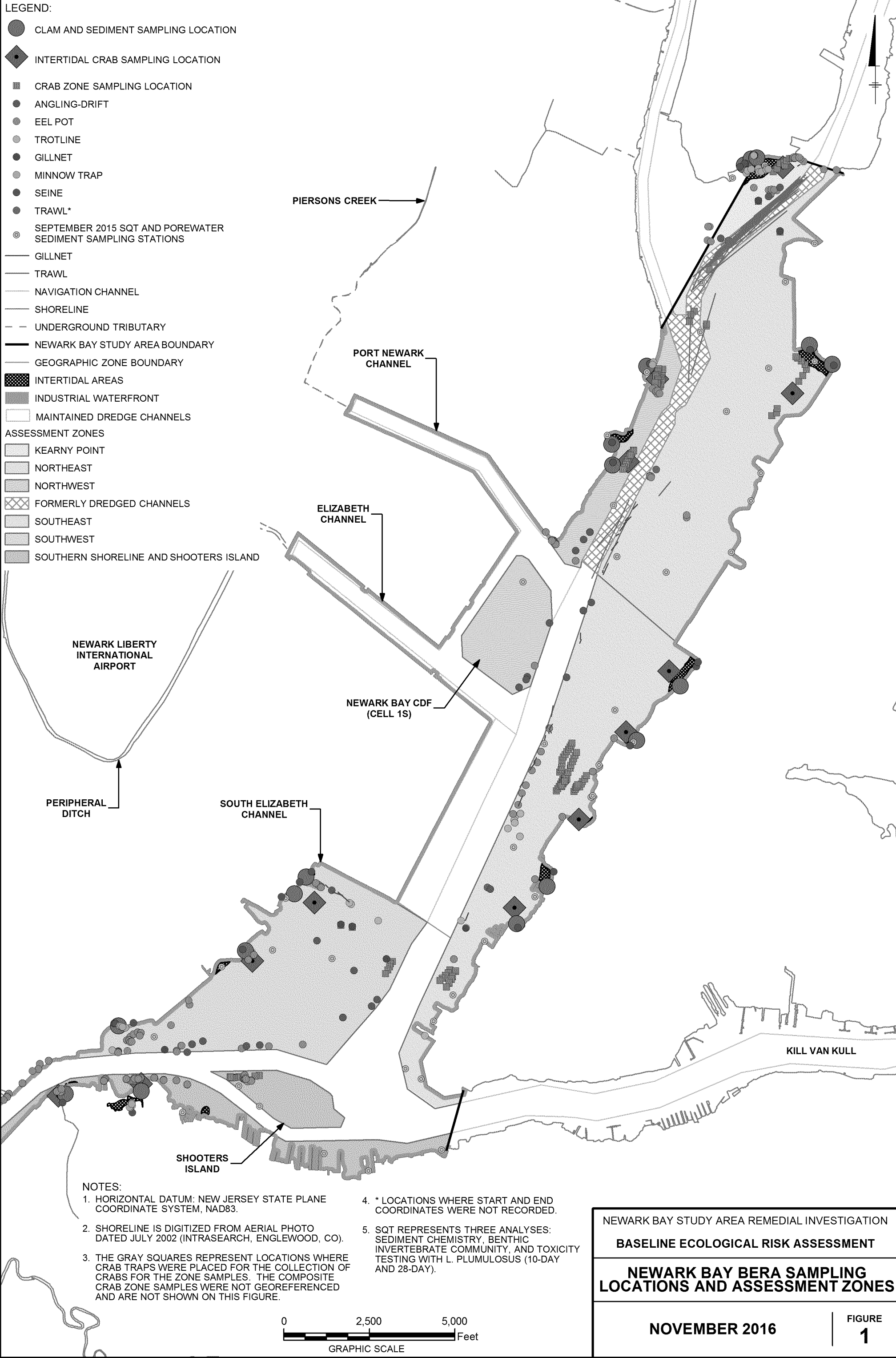


Table 1. Selected Receptors, Assessment Endpoints, and Measurement Endpoints for the NBSA BERA

Receptor Group and Assessment Endpoint	Risk Question	Measurement Endpoints	Data Use Objective	Biological Data/Media Sampled
Assessment Endpoint No. 1 - Survival, growth, and/or reproduction of invertebrates	Are invertebrate communities in the NBSA different from those found in similar nearby water bodies with chemical concentrations at regional background levels?	Community structure data (e.g., total invertebrate abundance, species richness, and abundance of species or specific taxonomic groups) and ecosystem characteristics data (e.g., grain size, TOC, and other attributes) from Newark Bay as compared with appropriate regional reference area background datasets using diversity indices, multivariate, and spatial statistical techniques.	Evaluating the data in the context of the overall health of the benthic community using the sediment quality triad approach, a sediment assessment technique that incorporates information about sediment chemistry, toxicity, and benthic community metrics.	Benthic invertebrate taxonomic survey and identification data.
	Are COPECs in invertebrate tissues from the NBSA greater than tissue toxicity reference values (TRVs) for the survival, growth, and/or reproduction of invertebrates?	COPEC concentrations in laboratory- exposed and/or site-collected invertebrate tissues (e.g., <i>Nereis virens</i> , <i>Mya arenaria</i> ) as compared with literature-based CBRs.	Assessing adverse effects of COPECs on the invertebrate community.	Site-collected invertebrate tissue from softshell clams ( <i>M. arenaria</i> ) and/or blue crabs; whole-body benthic infaunal invertebrate tissue from 28-day laboratory and/or field bioaccumulation tests using NBSA surface sediment.
	Are COPEC concentrations in sediments from the BAZ greater than benchmarks for the survival, growth, and/or reproduction of invertebrates?	COPEC concentrations in sediment as compared with toxicological sediment benchmarks from the literature.	Evaluating the effects of COPEC concentrations in sediment on the benthic invertebrate community of the NBSA.	Surficial sediment (from the BAZ) chemistry and conventional parameters.
	Is the survival, growth, and/or reproduction of invertebrates exposed to whole sediments from the BAZ of the NBSA significantly lower than that in reference sediments?	Laboratory toxicity tests (a 10-day and 28-day study with <i>Leptocheirus plumulosus</i> for survival, growth, and reproduction) using NBSA surface sediment statistically compared to bioassays conducted with control sediment.	Assessing the adverse effects of chemicals (and evaluation of conventional parameters such as grain size, TOC, sulfide, and ammonia) in sediment to the benthic invertebrate community.	Surficial sediment (from the BAZ) chemistry and conventional parameters.
	Are COPEC concentrations in porewater and surface water from the NBSA greater than benchmarks for the survival, growth, and/or reproduction of invertebrates?	Dissolved COPEC concentrations in porewater and surface water collected from benthic invertebrate exposure areas as compared with toxicological benchmarks.	Estimating the exposure of the benthic invertebrate community to COPECs the surface water and porewater exposure pathways.	Existing surface water dataset for NBSA; porewater data.
Assessment Endpoint No. 2 - Survival, growth, and/or reproduction of fish	Are COPEC concentrations in fish tissues from the NBSA greater than CBRs for the survival, growth, and/or reproduction of fish?	Whole-body and liver chemical analyses, and external health observations of identified fish receptors as compared with literature-based critical body residues and/or with whole-body fish tissue chemical concentrations of selected receptors from background locations.	Estimating the exposure of fish to COPECs in the NBSA.	Whole-body fish tissue chemical concentrations, liver chemical concentrations, gross histological analysis, and gross histology of representative species from each of three trophic levels (forage fish, benthic/demersal, and pelagic predatory).
	Are COPEC concentrations in porewater, surface water, and sediment from the NBSA greater than benchmarks for the survival, growth, and/or reproduction of fish?	COPEC concentrations in dissolved porewater and surface water collected from the NBSA as compared with toxicological benchmarks.	Estimating the exposure of fish via the surface water exposure pathway to COPECs in surface water.	Data (chemical and conventional parameters such as dissolved oxygen, salinity, pH, hardness) collected as part of the surface water monitoring program.
		COPEC concentrations in sediment as compared with toxicological sediment benchmarks from the literature.	Evaluating the effects of COPEC concentrations in sediment on fish populations in the NBSA.	Surface sediment collected from the BAZ.
		Reproductive health of fish collected from both the NBSA and a reference location assessed via morphology.	Evaluating the potential effects of COPECs on reproduction of NBSA fish.	Fish collected from the NBSA; existing ichthyoplankton dataset.
Assessment Endpoint No. 3 - Survival, growth, and/or reproduction of birds	Does the daily dose of COPECs received by birds (including piscivorous, benthivorous/sediment-probing, omnivorous, insectivorous birds) from consumption of the tissues of prey species and from other media in the NBSA exceed the TRVs for survival, growth, and/or reproduction of birds? If yes, what are the probabilities of effects of differing magnitude for survival, growth, and/or reproduction of birds?	Receptor-specific modeled daily doses associated with the ingestion of COPECs in surface water, sediment, and prey tissue as compared with literature-based dietary dose TRVs. COPEC concentrations in bird egg tissues may also be collected and compared to CBRs for bird eggs.	Estimating exposure of bird receptors via various exposure pathways to COPECs in surface water, sediment, and prey tissue. If potential risks are evident, a Probabilistic Risk Assessment may be conducted to quantify the uncertainties in the food web models.	Surface sediment chemistry (from the BAZ) and benthic invertebrate and/or fish prey tissue chemical concentrations, depending on receptor-specific diet. Bird egg tissue from the NBSA.
Assessment Endpoint No. 4 - Survival, growth, and/or reproduction of mammals	Does the daily dose of COPECs received by mammals (including piscivorous, omnivorous, and insectivorous) from consumption of the tissues of prey species and from other media in the NBSA exceed the TRVs for survival, growth, and/or reproduction of mammals? If yes, what are the probabilities of effects of differing magnitude for survival, growth, and/or reproduction of mammals?	Receptor-specific modeled daily doses associated with the ingestion of COPECs in surface water, sediment, and prey tissue as compared with literature-based dietary dose TRVs.	Estimating exposure of aquatic and semi-aquatic mammals to chemicals in NBSA surface water, sediment, and prey tissue. If potential risks are evident, a probabilistic risk assessment may be conducted to quantify the uncertainties in the food web models.	Surface sediment chemistry (from the BAZ) and benthic invertebrate and/or fish prey tissue chemical concentrations, depending on receptor-specific diet.

Notes:  
BAZ - biologically active zone  
BERA - baseline ecological risk assessment  
COPEC - constituent of potential ecological concern  
CBR - critical body residue  
NBSA - Newark Bay Study Area  
TOC - total organic carbon  
TRV - toxicity reference value

**Table 2. Representative Receptors for the NBSA BERA**

Receptor Group	Receptor Guild and Habitat	Site Use	Species
Benthic Invertebrates	Benthic, filter-feeder, marine	Resident	Soft-shell clam
	Benthic omnivore, marine	Resident	Blue crab
Fish	Forage fish	Resident	Mummichog
	Benthic omnivore	Migratory	Summer/winter flounder
	Pelagic invertivore	Migratory	White perch
	Pelagic piscivore migratory	Migratory	American eel
Birds	Benthivore/sediment-probing	Migratory	Spotted sandpiper
	Subtidal piscivore	Migratory	Great blue heron
	Pelagic piscivore	Migratory	Double-crested cormorant
	Omnivore	Migratory	Lesser Scaup
Mammals	Insectivore	Migratory	Marsh wren
	Piscivore	Transient	River otter
	Omnivore	Resident	Muskrat
	Piscivore	Transient	Harbor seal

**Notes:**

BERA = baseline ecological risk assessment

NBSA = Newark Bay Study Area

Table 3. Exposure Parameters for Representative Bird Receptors

Focal Species	Guild	Body Weight (kg) <sup>a</sup>	Food Ingestion		Incidental Sediment Ingestion			WIR (L/day) <sup>c</sup>	Diet			Site Use	
			FIR (kg dw/day)	Source	SI (%) <sup>b</sup>	SIR (kg dw/day)	Source		Reported Diet	Source	Proposed Diet Composition (NBSA diet items)	SUF	Source
Spotted sandpiper	Benthivore/sediment-probing	0.043	0.009	Nagy (2001), Charadriiformes (eq. 39)	18 <sup>d</sup>	0.00168	Beyer et al. (1994)	NA	Benthic invertebrates	USEPA (1993)	100% benthic invertebrates (polychaete data)	0.5	Reed et al. (2013)
Great blue heron	Subtidal piscivore	2.300	0.201	Nagy (2001), Charadriiformes (eq. 39)	1	0.00201	No empirical data available; based on feeding habits and best professional judgment.	NA	Invertebrates, mollusks, fish	USEPA (1993)	80% forage fish, 10% clams, 10% blue crab	1	Vennesland and Butler (2011)
Double-crested cormorant	Pelagic piscivore	2.330	0.145	Nagy (2001), marine birds (eq. 52)	0	0.00	No empirical data available; based on feeding habits and best professional judgment.	NA	Mollusks, clams, fish	Dorr et al. (2014)	100% fish (mixed species)	1	Dorr et al. (2014)
Lesser scaup	Omnivore	0.815	0.045	Nagy (2001), omnivorous birds (eq. 61)	4.7	0.00211	Beyer et al. (2008)	NA	Aquatic plants and invertebrates, crustaceans, fish	USEPA (1993)	25% sediment (surrogate for vegetation), 25% benthic invertebrates (polychaete data), 25% blue crab, 25% fish (mixed species)	0.5	Anteau et al. (2014)
Marsh wren	Insectivore	0.011	0.001	Nagy (2001), passerine birds (eq. 37)	0	0.00	No empirical data available; based on feeding habits and best professional judgment.	NA	Terrestrial invertebrates	USEPA (1993)	100% benthic invertebrates (polychaete data)	0.75	Kroodsma and Verner (2013)

Notes:

<sup>a</sup> Average of male and female adult body weights reported by USEPA (1993) for all species except cormorant. CalEcotox (1999) for cormorant

<sup>b</sup> Percentage of the dry diet that is incidentally ingested sediment.

<sup>c</sup> Assumed no NBSA surface water ingestion because it is saltwater.

<sup>d</sup> Based on the average of SIRs measured for four sandpiper species (stilt sandpiper [*Calidris himantopus*] [17%], semipalmated sandpiper [*Calidris pusilla*] [30%], least sandpiper [*Calidris minutilla*] [7.3%], and western sandpiper [*Calidris mauri*] [18%]).

dw - dry weight  
eq. - equation  
FIR - food ingestion rate  
kg - kilograms  
L - liters  
NA - not applicable  
NBSA - Newark Bay Study Area  
SI - sediment ingestion  
SIR - sediment ingestion rate  
SUF - site use factor  
WIR - water ingestion rate  
USEPA - United States Environmental Protection Agency



**Table 4. Bird and Mammal Receptor Exposure Areas for Risk Assessment**

Receptor Species	Exposure Area (see Figure 1)	
	Prey Consumption	Incidental Sediment Ingestion
<b>Birds</b>		
<b>Marsh wren</b>	NBSA-wide mudflats <sup>a</sup>	NBSA-wide mudflats <sup>a</sup>
	Individual mudflats	Individual mudflats
<b>Lesser scaup</b>	NBSA-wide <sup>a</sup>	NBSA-wide <sup>a</sup>
	Assessment zones within NBSA	Assessment zones within NBSA
<b>Spotted sandpiper</b>	NBSA-wide mudflats <sup>a</sup>	NBSA-wide mudflats <sup>a</sup>
	Individual mudflats	Individual mudflats
<b>Great blue heron</b>	NBSA-wide	NBSA-wide mudflats <sup>a</sup>
	Assessment zones within NBSA	Mudflats by assessment zone within NBSA
<b>Double-crested cormorant</b>	NBSA-wide	No incidental sediment ingestion
	Assessment zones within NBSA	Assessment zones within NBSA
<b>Mammals</b>		
<b>River otter</b>	NBSA-wide	NBSA-wide
	Assessment zones within NBSA	Assessment zones within NBSA
<b>Muskrat</b>	NBSA-wide shoreline areas	NBSA-wide shoreline areas
	Shoreline areas by assessment zone within NBSA	Shoreline areas by assessment zone within NBSA
<b>Harbor seal</b>	NBSA-wide	NBSA-wide
	Assessment zones within NBSA	Assessment zones within NBSA

**Notes:**

<sup>a</sup>Mudflats are defined as intertidal areas within -2 feet MLLW and < 6° slope and include all grain sizes.

MLLW - mean lower low water

NBSA - Newark Bay Study Area

Table 5. Exposure Parameters for Representative Mammal Receptors

Focal Species	Guild	Body Weight (kg) <sup>a</sup>	Food Ingestion		Incidental Sediment Ingestion			WIR (L/day) <sup>b</sup>	Diet			SUF
			FIR	Source	SI	SIR	Source		Dietary Items	Source	Proposed Diet Composition (NBSA Diet)	
			(kg dw/day)		(%)	(kg dw/day)						
River otter	Piscivorous	8	0.240	Nagy (2001), Carnivora (eq. 9)	2	0.0048	No empirical data available; based on feeding habits and best professional judgment	NA	Fish, shellfish, aquatic insects, waterfowl	USEPA (1993)	80% fish, 10% clams, 5% benthic invertebrates (polychaete data), 5% blue crab	0.5
Muskrat	Omnivorous or herbivorous	1	0.070	Nagy (2001), Rodentia (eq. 11)	2.8	0.00195	Assumed to be similar to hispid cotton rat (Garten 1980)	NA	Aquatic vegetation, fish, mollusks	USEPA (1993)	85% sediment (surrogate for vegetation), 10% fish, 5% clams	1
Harbor seal	Piscivorous	80	1.12 <sup>c,d</sup>	Ashwell-Erickson and Elsner (1981)	2	0.0224	No empirical data available; based on feeding habits and best professional judgment	NA	Fish, shellfish	USEPA (1993)	90% fish, 5% clams, 5% blue crab	0.5

Notes:

<sup>a</sup> Average of male and female adult body weights reported in USEPA (1993).

<sup>b</sup> Assumed no NBSA surface water ingestion because it is saltwater.

<sup>c</sup> Dry weight FIR estimated from wet weight FIR assuming 80% moisture in the diet. Percent moisture value used in FIR calculation will be adjusted based on actual percent moisture in NBSA collected diet items.

<sup>d</sup> FIR = 7% of body weight on average (range reported was 6 to 8%).

BERA - baseline ecological risk assessment

BW - body weight

dw - dry weight

eq. - equation

FIR - food ingestion rate

GE - gross energy

kg - kilograms

L - liters

NA - not applicable

NBSA - Newark Bay Study Area

SI - sediment ingestion

SIR - sediment ingestion rate

SUF - site use factor

USEPA - United States Environmental Protection Agency

WIR - water ingestion rate

ww - wet weight



Table 6. Preliminary Benthic Invertebrate Tissue Toxicity Reference Values

Preliminary List of COPECs	Units (Wet Weight)	Range and Source of Preliminary TRVs					
		NOAEL	LOAEL	Endpoint	Organism	Source	Notes on Differences from LPRRP BERA
Inorganics/Metals							
Arsenic	mg/kg	ND	20	Mortality	Periwinkle snail	Klumpp (1980)	Lowest marine LOAEL
Cadmium	mg/kg	ND	0.45	Reproduction	Copepod	Hook and Fisher (2002)	Lowest marine LOAEL
Chromium	mg/kg	4.4	6	Reproduction	Polychaete worm	Oshida and Word (1982)	
Cobalt	mg/kg						No TRV available
Copper	mg/kg	ND	9.3	Mortality	Little neck clam	Roesijadi (1980)	Lowest marine LOAEL
Lead	mg/kg	ND	200	Mortality	Indian prawn shrimp	Chinni et al. (2002)	Lowest marine LOAEL
Mercury/Methylmercury	µg/kg	48	95	Reproduction	Copepod	Hook and Fisher (2002)	Lowest marine values
Nickel	mg/kg	ND	1.1	Mortality	Amphipod	Borgmann et al. (2001)	
Selenium	mg/kg	0.05	0.51	Growth	Midge	Malchow et al. (1995)	
Silver	mg/kg	0.59	0.49	Growth	Cladoceran ( <i>Daphnia</i> )	Naddy et al. (2007)	
Vanadium	mg/kg	0.8	ND	Mortality	Sea cucumber	Miramand et al. (1982)	Highest marine NOAEL, no reported LOAELs
Zinc	mg/kg	ND	28	Mortality/growth	Amphipod	Ahsanullah and Williams (1991)	Lowest marine LOAEL
PAHs							
Total PAHs	µg/kg	ND	23,200	Growth	Polychaete worm	Rice et al. (2000)	Based on benzo(a)pyrene; lowest marine LOAEL
PCDDs/PCDFs							
Total TEQ	ng/kg	ND	2	Reproduction	Bivalves (oyster and soft shell clam)	Cooper and Wintermeyer (2009)	Lowest marine LOAEL
PCBs							
Total PCBs	µg/kg	8	26	Reproduction	Eastem oyster	Chu et al. (2000); Chu et al. (2003)	Lowest marine values
Organochlorine Pesticides							
Total DDTx	µg/kg	60	130	Mortality	Pink shrimp	Nimmo et al. (1970)	Lowest marine values
Dieldrin	µg/kg	1.6	8	Survival	Pink shrimp	Parrish et al. (1973)	Lowest marine values
Chlordane	µg/kg	710	1,700	Mortality	Pink shrimp	Parrish et al. (1976)	Lowest marine values
Hexachlorobenzene	µg/kg	ND	15,800	Mortality	Amphipod	Nebeker et al. (1989)	Lowest LOAEL, freshwater amphipod

**Notes:**

BERA - baseline ecological risk assessment

COPEC – constituent of potential ecological concern

DDTx – dichlorodiphenyltrichloroethane and metabolites

LOAEL – lowest observed adverse effect level

mg/kg – milligrams per kilogram

ng/kg – nanograms per kilogram

ND - not derived

NOAEL – no observed adverse effect level

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

PCDD – polychlorinated dibenzo-*p*-dioxin

PCDF – polychlorinated dibenzofuran

TEQ – toxicity equivalency factor

TRV – toxicity reference value

µg/kg – micrograms per kilogram

Table 7. Preliminary Fish Tissue Toxicity Reference Values

Preliminary List of COPECs	Units (Wet Weight)	Range and Source of Preliminary TRVs					
		NOAEL	LOAEL	Endpoint	Species	Source	Notes on Differences from LPRRP BERA
Inorganics/Metals							
Arsenic	mg/kg	1.3	2.5	Growth	Rainbow trout	Erickson et al. (2011)	
Cadmium	mg/kg	ND	0.12	Growth	Atlantic salmon	Rombough and Garside (1982)	
Chromium	mg/kg	1.3	1.3	Mortality	Chinook salmon	Farag et al. (2006)	
Cobalt	mg/kg						No TRVs available
Copper	mg/kg	3.9	4.5	Mortality	Rainbow trout	Mount et al. (1994)	
Lead	mg/kg	2.6	4.0	Growth	Brook trout	Holcombe et al. (1976)	
Mercury/Methylmercury	µg/kg	6.5	470	Mortality	Mummichog	Matta et al. (2001)	Lowest marine values
Nickel	mg/kg						No TRVs available
Selenium	mg/kg	ND	2.1	Growth	Chinook salmon	Hamilton et al. (1990)	
Silver	mg/kg	0.11	0.24	Mortality	Rainbow trout	Guadagnolo et al. (2001)	
Vanadium	mg/kg						No TRVs available
Zinc	mg/kg	ND	45	Mortality/growth	American flagfish	Spehar (1976)	
PCDDs/PCDFs							
Total TEQ	ng/kg	122	300	Growth	Mummichog	Salomon (1995)	
PCBs							
Total PCBs	µg/kg	760	3,800	Reproduction	Mummichog	Black et al. (1998)	
Organochlorine Pesticides							
Total DDTx	µg/kg	1,800	1,800	Mortality	Cutthroat trout	Allison et al. (1964)	
Dieldrin	µg/kg	120	200	Survival	Rainbow trout	Shubat and Curtis (1986)	
Chlordane	µg/kg	ND	16,600	Mortality	Pinfish	Parrish et al. (1976)	Lowest marine LOAEL
Hexachlorobenzene	µg/kg	468,000	ND	Mortality	Fathead minnow	Schuytema et al. (1990)	Highest available NOAEL

**Notes:**

BERA - baseline ecological risk assessment

COPEC – constituent of potential ecological concern

CPG – Cooperating Parties Group

DDTx – dichlorodiphenyltrichloroethane and metabolites

LOAEL – lowest observed adverse effect level

LPRRP - Lower Passaic River Restoration Project

mg/kg – milligrams per kilogram

ng/kg – nanograms per kilogram

ND - not derived

NOAEL – no observed adverse effect level

PCB – polychlorinated biphenyl

PCDD – polychlorinated dibenzo-*p*-dioxin

PCDF – polychlorinated dibenzofuran

TEQ – toxicity equivalency factor

TRV – toxicity reference value

µg/kg – micrograms per kilogram

**Table 8. Preliminary Bird Dietary Toxicity Reference Values**

Preliminary List of COPECs	Units	Range and Source of Preliminary TRVs					
		NOAEL	LOAEL	Endpoint	Species	Source	Notes on Differences from LPRRP BERA
Inorganics/Metals							
Arsenic							No TRV available
Cadmium	mg/kg bw/day	0.4	4	Growth	Japanese quail	Richardson et al. (1974)	
Chromium	mg/kg bw/day	10.5	105	Survival and Growth	Chicken	Chung et al. (1985)	
Cobalt							No TRV available
Copper	mg/kg bw/day	1.9	19	Growth	Chicken	Jensen and Maurice (1978)	
Lead	mg/kg bw/day	5.5	28	Growth	Japanese quail	Morgan et al. (1975)	
Mercury/Methylmercury	µg/kg bw/day	ND	96	Growth, Reproduction, and Mortality	American kestrel, great egret, Japanese quail, mallard, northern bobwhite, and zebra finch	Windward (2016) <sup>a</sup>	
Nickel	mg/kg bw/day	10.7	107	Mortality and Growth	Mallard	Cain and Pafford (1981)	Lowest LOAEL, non-domestic chicken species
Selenium	mg/kg bw/day	0.42	0.82	Reproduction	Mallard	Heinz et al. (1989)	
Silver							No TRV available
Vanadium	mg/kg bw/day	1.2	2.3	Growth	Chicken	Ousterhout and Berg (1981)	
Zinc	mg/kg bw/day	ND	300	Mortality	Mallard	Gasaway and Buss (1972)	Lowest LOAEL, non-domestic chickent species.
PAHs							
Benzo(a)pyrene	µg/kg bw/day	140	1,400	Reproduction	Pigeon	Hough el al. (1993)	
Total PAHs	µg/kg bw/day	40,000	NA	Growth	Mallard	Patton and Dieter (1980)	
PCDDs/PCDFs							
Total TEQ	ng/kg bw/day	14	140	Mortality, Growth and Reproduction	Ring-necked pheasant	Nosek et al. (1992)	
PCBs							
Total PCBs	µg/kg bw/day	140	1,400	Reproduction	Ringed turtle-dove	Peakall et al. (1972); Peakall and Peakall (1973)	
Organochlorine Pesticides							
Total DDTx	µg/kg bw/day	ND	250	Reproduction and Mortality	Ten species	Windward (2016) <sup>a</sup>	
Dieldrin	µg/kg bw/day	80	120	Mortality	Quail	Davison and Sell (1974)	
Chlordane	µg/kg bw/day	ND	20,000	Mortality	Bobwhite	Hill et al. (1975); Heath et al. (1972)	Lowest LOAEL in CPG TRV database.
Hexachlorobenzene	µg/kg bw/day	1,100	5,000	Mortality	Japanese quail	Vos et al. (1971)	Lowest values in CPG database

**Notes:**

<sup>a</sup>The LOAEL represents the 5th percentile of a species sensitivity distribution developed by Windward (2016)

BERA - baseline ecological risk assessment  
 bw – body weight  
 COPEC – constituent of potential ecological concern  
 CPG - Cooperating Parties Group  
 DDTx – dichlorodiphenyltrichloroethane and metabolites  
 LOAEL – lowest observed adverse effect level  
 LPRRP - Lower Passaic River Restoration Project  
 mg/kg – milligrams per kilogram  
 ND – not derived  
 ng/kg – nanogram per kilogram  
 PAH – polycyclic aromatic hydrocarbon  
 PCB – polychlorinated biphenyl  
 PCDD – polychlorinated dibenzo- *p* -dioxin  
 PCDF – polychlorinated dibenzofuran  
 NOAEL – no observed adverse effect level  
 SSD – species sensitivity distribution  
 TEQ – toxicity equivalency factor  
 TRV – toxicity reference value  
 µg/kg – micrograms per kilogram

**Table 9. Preliminary Bird Egg Tissue Toxicity Reference Values for Select Bioaccumulative Compounds**

COPEC	Units (Wet Weight)	Range and Source of Preliminary TRVs				
		NOAEL	LOAEL	Endpoint	Species	Source
Inorganics/Metals						
Mercury/methylmercury	µg/kg	180	1800	Reproduction	Mallard	Heinz (1979); Heinz and Hoffman (2003); Heinz (1976, 1974)
PCDDs/PCDFs						
Total TEQ	ng/kg	ND	250	Reproduction	Double-crested cormorant, great blue heron, Japanese quail, pigeon, and ring-necked pheasant	Windward (2016) <sup>a</sup>
PCBs						
Total PCBs	µg/kg	1,600	16,000	Reproduction	Ringed turtle dove	Peakall et al. (1972); Peakall and Peakall (1973)
Organochlorine Pesticides						
Total DDTx	µg/kg	ND	10,700	Reproduction	American kestrel, barn owl, black duck, Japanese quail, mallard, and ring-necked pheasant	Windward (2016) <sup>a</sup>
Dieldrin	µg/kg	300	3,000	Reproduction	Pheasant	Genelly and Rudd (1956)
Chlordane	µg/kg					No TRVs available
Hexacholorbenzene	µg/kg					No TRVs available

**Notes:**

<sup>a</sup>The LOAEL represents the 5th percentile of a species sensitivity distribution developed by Windward (2016).

COPEC – constituent of potential ecological concern

DDTx – dichlorodiphenyltrichloroethane and metabolites

LOAEL – lowest observed adverse effect level

ND – not derived

ng/kg – nanograms per kilogram

NOAEL – no observed adverse effect level

PCB – polychlorinated biphenyl

PCDD – polychlorinated dibenzo-*p*-dioxin

PCDF – polychlorinated dibenzofuran

TEQ – toxicity equivalency factor

TRV – toxicity reference value

µg/kg – micrograms per kilogram

**Table 10. Preliminary Mammal Dietary Toxicity Reference Values**

COPEC	Units	Range and Source of Preliminary TRVs				
		NOAEL	LOAEL	Endpoint	Species	Source
Inorganics/Metals						
Arsenic	mg/kg bw/day	0.32	4.7	Growth NOAEL/ cellular LOAEL	Rat	Schroeder et al. (1968); Brown et al. (1976); cited in USEPA (2002)
Cadmium	mg/kg bw/day	1.14	2.28	Reproduction	Mouse	Sawicka-Kapusta et al. (1994); cited in USEPA (2005a)
Chromium	mg/kg bw/day	ND	9.62	Reproduction	Mouse	Zahid et al. (1990) in USEPA (2008)
Cobalt	mg/kg bw/day	5.5	10.9	Reproduction	Rat	Domingo et al. (1985) in USEPA (2005b)
Copper	mg/kg bw/day	3.4	6.8	Reproduction	Mink	Aulerich et al. (1982) as cited in USEPA (2007a)
Lead	mg/kg bw/day	0.71	7	Reproduction	Rat	Grant et al. (1980) as cited in USEPA (2005c)
Mercury/Methyl Mercury	mg/kg bw/day	0.27	0.16	Growth/survival	Mink	Wobeser et al. (1976) in USEPA (1995)
Nickel	mg/kg bw/day	0.133	31.6	Reproduction	Rat	Smith et al. (1993) as cited in USEPA (2002)
Selenium	mg/kg bw/day	0.368	0.564	Reproduction	Rat	Abdo (1994) as cited in USEPA (2007b)
Silver	mg/kg bw/day	ND	188	Reproduction	Rat	Shavlovski et al. (1995) as cited in USEPA (2006)
Vanadium	mg/kg bw/day	4.16	8.3	Reproduction	Rat	Sanchez et al. (1991) as cited in USEPA (2005d)
Zinc	mg/kg bw/day	9.6	411	Pancreas, adrenal cortex NOAEL/reproduction LOAEL	Mouse/rat	Aughey et al. (1977) (NOAEL); Schlicker & Cox (1968) (LOAEL), both as cited in USEPA (2002)
PAHs						
Total PAHs	mg/kg bw/day	0.615	307	Survival	Mouse	As cited in USEPA (2007c)
PCDDs/PCDFs						
Total TEQ	ng/kg bw/day	2.6	8.8	Reproduction	Mink	Hochstein et al. (2001)
PCBs						
Total PCBs	µg/kg bw/day	80	96	Reproduction	Mink	Chapman (2003)
Organochlorine Pesticides						
Total DDTx	µg/kg bw/day	ND	1300.0	Reproduction	Mouse	Ware and Good (1967)
Dieldrin	µg/kg bw/day	15	30	Reproduction	Rat	Harr et al. (1970)
Chlordane						No TRV available
Hexachlorobenzene	µg/kg bw/day	NA	130	Reproduction	Mink	Bleavins et al. (1984)

**Notes:**

bw – body weight

COPEC – constituent of potential ecological concern

DDTx – dichlorodiphenyltrichloroethane and its metabolites

LOAEL – lowest observed adverse effect level

mg/kg – milligrams per kilogram

ng/kg – nanograms per kilogram

ND - not derived

NOAEL – no observed adverse effect level

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

PCDD – polychlorinated dibenzo-*p*-dioxin

PCDF – polychlorinated dibenzofuran

TEQ – toxicity equivalency factor

TRV – toxicity reference value

µg/kg – micrograms per kilogram